Asian Journal of Distance Education

The SETI Framework and Technology Integration in the Digital Age

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Abstract: Effective integration of technology is critical for online, blended, hybrid, and face-to-face learning. The purpose of this paper is to introduce the SETI (Socio-Ecological Technology Integration) framework and explain what it adds to the scholarly research regarding effective technology integration. The SETI framework goes beyond previous frameworks and applies a holistic systems approach to understanding effective technology integration. This takes into account all aspects of technology integration including new findings uncovered during the Covid-19 lockdown. TPACK and SAMR were analyzed identifying their benefits and limitations and then the SETI framework was explained providing insight into the value of a whole systems approach to technology integration.
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Keywords: SAMR, SETI, Technology Integration framework, Socio ecological, TPACK.

Highlights

What is already known about this topic:

- The TPACK and SAMR frameworks are commonly used in education and were developed to help educators understand how to effectively integrate technology into curriculum.
- TPACK and SAMR focus only on the role of the teacher in technology integration.
- TPACK and SAMR do not consider the diverse contexts and other factors that influence technology integration.

What this paper contributes:

- This paper contributes to the literature by providing a description of the SETI framework for technology integration which considers all the socio-ecological factors that are involved in effective technology integration.
- The paper also adds to the understanding that, for teachers to effectively integrate technology into teaching and learning, the entire social and ecological system needs to be considered.

Implications for theory, practice and/or policy:

- The paper demonstrates how SETI framework can be used to close the gap left by TPACK and SAMR frameworks that highlight the community effort needed for effective technology integration. SETI demonstrates the need to identify the socio-ecological systems surrounding educators for effective technology integration.
- SETI highlights the need for multiple resources and structures that need to be in place for technology integration, including training, technology support, policies, and infrastructure.
- The SETI framework also highlights the importance of national and individual cultures and beliefs in technology integration.

Published by Asian Society for Open and Distance Education (ASODE), Japan
ISSN 1347-9008 http://www.asianjde.com/

Introduction

The integration of technology is widespread in education and educators integrate technological tools for multiple purposes, including increasing knowledge acquisition (Saltan & Arslan, 2017) and boosting overall academic achievement (Yilmaz, 2018). Technology integration is also positively associated with affective conditions that can enhance learning outcomes, such as motivation and attention (Ibáñez et al., 2020). Education in the online format inherently includes technologies. Nonetheless, the level of integration can vary from talking heads as the educator lectures to a computer screen to online formats that facilitate cooperative learning (Ivone et al., 2020). While teaching and learning online may be widespread, there are many challenges to the use of technology in online classes (Ruipérez-Valiente, 2022).

Both national and international standards (ISTE, 1998, 2007, 2016; US Department of Education, 2016) highlight that technologies should be integrated into the curriculum through careful consideration. Ensuring positive learning gains requires educators to integrate technology into their classrooms effectively. However, empirical findings show that educators are not always integrating technology effectively into the curriculum (Kurt et al., 2013). Educators can often use technology primarily for low-level tasks, such as drill and practice programs or free time activities (Chen et al., 2014; Hsu, 2012, 2013; Tondeur et al., 2012).

As the use of technology in teaching and learning will only continue to grow, educators must understand how to effectively integrate the use of technology into their practice. In the recent past, technology integration frameworks have been developed to help educators think about how to best integrate technology and to provide a lens through which they can articulate how and why they integrate technology. Two frequently used integration frameworks are the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006) and the Substitution, Augmentation, Modification Redefinition (SAMR) framework (Puentedura, 2009). These frameworks highlight what the educator should be doing to integrate technology into education.

The purpose of this paper is to present an argument for the need for the new Socio-Ecological Technology Integration (SETI) framework and explain what it adds to the scholarly research regarding effective technology integration. The SETI framework applies a holistic systems approach to understanding effective technology integration. A description of previously developed frameworks, TPACK and SAMR, will be analyzed, identifying their benefits and limitations, and then the SETI framework will be explained, providing insight into the value it adds to current thinking about effective technology integration.

Technology Integration in Education

With the rapid advancement of digital technologies available for use in education (Baker et al., 2019) and the call by both national and international organizations regarding the importance of the use of technology in education (ISTE, 1998, 2007, 2016; US Department of Education, 2016), the effective integration of technology into educational practice is critical for both online, blended, hybrid, and face to face learning. Effective integration of technology provides numerous benefits to both educators and learners. When digital technology is integrated into curriculum delivery, learners can easily acquire supportive learning materials (Hodgson & Shah, 2017). This helps to improve access to information, enhance communication, and increase efficiency in curriculum delivery (Celik, 2023; Chigona, 2018).

However, integrating technology is not without its challenges (Hodgson & Shah, 2017; Paudel, 2021). Some challenges are inadequate infrastructure, training, and support for educators and learners (Akram et al., 2022). Educators need various supports for effective technology integration, including digital pedagogical strategies, frameworks, digital tools, equitable practice, and mental wellness supports (Crompton et al., 2023). It is important to examine technology integration frameworks to unpack the underpinning message about how technology can be integrated effectively into education.

Technology Integration Frameworks

This section highlights the two popular technology integration frameworks, TPACK and SAMR, before moving on to a description of the SETI framework and what it adds to the understanding of technology integration.

TPACK

As education digital technologies advanced, educator technology training was focused on technology skills, assuming that educators would naturally understand how to integrate the technology within their curriculum. However, this assumption was not accurate, and it became clear that knowledge of technology did not necessarily lead to effective teaching with technology (Thompson & Mishra, 2007).

In 2007, the TPACK framework (see Figure 1) was timely as technologies were exponentially seeping into the educational space and educators were exploring how to use the technologies in the educational context. Academics have used TPACK with both preservice (e.g., Kalogiannakis, & Papadakis, 2022) and in service teachers (e.g., Papadakis, 2022) to explore educators thinking and practice in the use of technology for education. The framework was created in response to both the technocentric focus (Mishra & Koehler, 2006) and a lack of conceptual frameworks to explain successful technology integration in the classroom (Issroff & Scanlon, 2002). Shulman (1986) first presented a framework in 1986 that highlighted that educators should have knowledge in both pedagogy and content knowledge and consider the interconnected nature between the two areas.

Mishra and Koehler sought to expand on Shulman's (1986) concept of pedagogical content knowledge (PCK), which posited that there is an important relationship between educators' knowledge of subject matter and their knowledge of pedagogical strategies for teaching that subject. With the digital revolution, Koehler and Mishra (2008) revised Shulman's framework to include technological knowledge as a third area. This framework was important as earlier technology integration efforts primarily focused on educators building technology skills and did not consider how those technologies should be integrated with pedagogies and the academic goals and objectives of the lessons (Crompton, 2017).

TPACK adds the technology knowledge domain to PCK, highlighting the interrelationship of an educator's knowledge of technology, content, and pedagogy and the impact that interrelationship has on effective technology integration (Herring et al., 2016; Koehler et al., 2014). The authors posited that the framework could transform how technology integration is addressed in teacher education, training, professional development, and research (Mishra & Koehler, 2006).

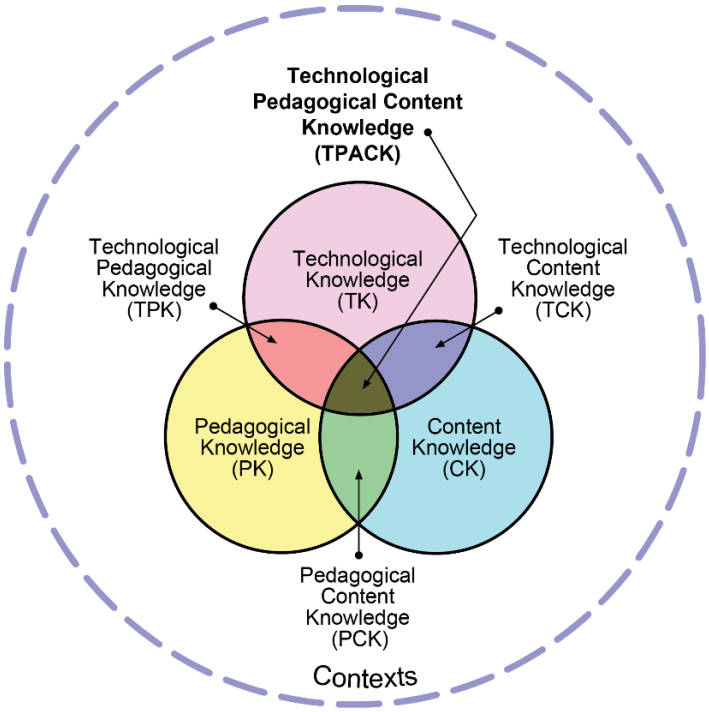

Figure 1. TPACK Framework (Mishra & Koehler, 2006)

The overlapping circles of the TPACK framework represent the three major knowledge domains: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technology Knowledge (TK). The overlapping areas of the circles represent the interplay between the knowledge domains, resulting in Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical (TPK), and Technological Pedagogical Content Knowledge (TPACK). The dotted outer circle, labeled Contexts, signifies the unique, dynamic relationship between content, pedagogical, and technological knowledge within the context it is situated (Hunter, 2015; Koehler et al., 2014; Mishra & Koehler, 2006).

Scholars have critiqued the TPACK framework, providing insights into its challenges. Angeli and Valanides (2009) found that educators struggle to see the boundaries between technology, pedagogy, and content knowledge. Chai et al (2011) also noted that TPACK had uneven intersections and that some areas appeared more important than others. It is also important to note that TPACK highlights the knowledge of the educator for technology integration, directing the emphasis that it is the responsibility of the educator alone for technology integration. TPACK does not include factors beyond the realm of instructional practices that can influence effective technology integration.

SAMR

The SAMR framework also focuses its attention exclusively on the pedagogical decisions that educators make when planning their instruction. Again, this puts all the expectations for effective integration on the educator. SAMR is represented as a ladder, see Figure 2. The four hierarchical levels encourage moving from the two lower rungs, which signify how technology can enhance learning, to the two higher rungs, which represent ways that technology integration can promote the transformation of learning (Blundell et al., 2022). At the lowest level, Substitution, digital technology replaces more traditional analog technology, but there is no resulting functional change (Puentadera, 2009). An example of this level is substituting digital versions of a math test review for traditional hard paper copies (Hamilton et al., 2016). On the second level, Augmentation, the technology change is still a direct substitute for the original technology. However, it results in some functional improvement (Hunter, 2015), such as replacing a paper map with Google Earth to measure the distance between two places (Crompton, 2017).

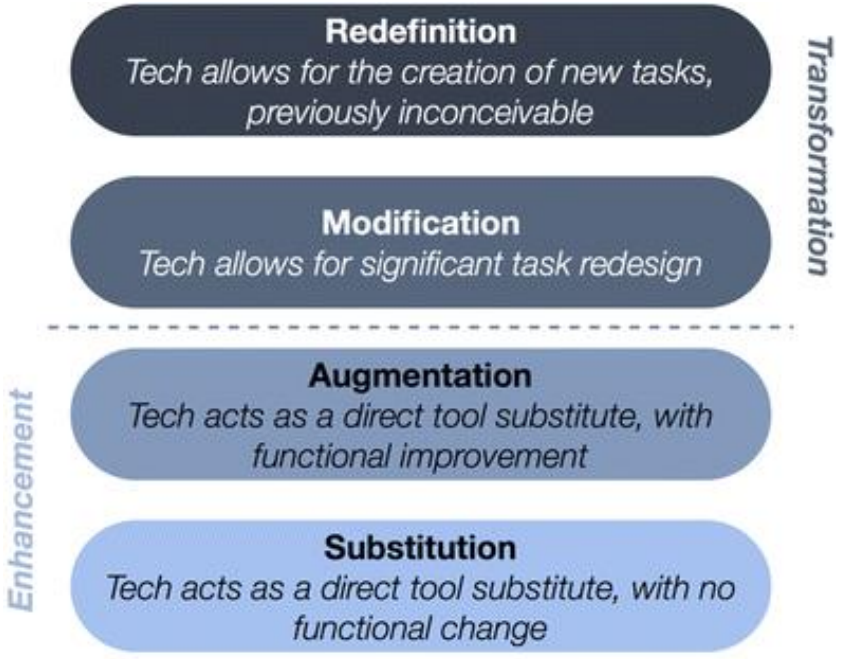

Figure 2. SAMR Model (Puentadera, 2009)

The third and fourth levels of the model represent opportunities for transforming learning experiences. On the third level, Modification, the chosen technology allows for significantly redesigning the learning task, such as students interacting with a computer simulation of how light travels (Hamilton et al., 2016) instead of viewing a static diagram. The highest level, Redefinition, represents the use of technology to

create novel learning tasks that were previously inconceivable (Hunter, 2015), such as creating virtual field trips (Caukin & Trail, 2019).

In 2009, when Puentedura presented the SAMR framework, educators were aligning their strategies with TPACK and integrating technologies; however, educators often used technology to replicate existing teaching strategies rather than maximize the affordances that technologies can provide (Tondeur et al., 2012). The SAMR framework helped educators further consider how technology was being used and if it was extending and enhancing learning or if the same outcome could be produced without technology; however, like TPACK it does not take into consideration factors beyond the classroom teacher that impact technology integration.

Again, scholars (viz., Crompton & Burke, 2020) have critiqued the SAMR framework with the lack of theoretical explanation of each of the levels and the lack of context when making decisions on how technology is used, there are problems with the rigid hierarchical structure. Furthermore, the framework places emphasis on the product over the process of technology integration.

SETI

While both the TPACK and SAMR frameworks are important in helping educators think about technology integration, both frameworks failed to acknowledge the variety of the socio-ecological factors involved in technology integration. Technology integration is more than just having technologies. Schools do not exist in a vacuum, and effective technology integration requires awareness of a full systems approach to technology integration. Awareness of this need to consider factors beyond the educator led to the development of the social-ecological technology integration (SETI) framework (Crompton et al., 2023) which highlights the integration of technology by educators within the context of various systems and the connected socio-ecological factors. This framework was developed in response to the call for the need to include factors beyond the educator and the classroom (Engen & Engen, 2019). The SETI framework is based on Crompton's (2017) version and has been updated to include additional factors in 2023. The SETI framework highlights the physical environment, which includes resources, such as available technologies, and the social ecology of interactions between people within those contexts. To effectively understand how to best integrate technology, the entire social and ecological system needs to be considered.

The SETI framework first emerged from the literature in 2017 from a thematic systematic review of the literature examining the integration of mobile learning in teaching and learning (Crompton, 2017). The initial study used an inductive and deductive coding approach to scrape empirical literature to uncover the factors that were connected with technology integration. The findings revealed four major themes: teacher beliefs, resources, methods, and purpose. Each part encompassed multiple sub-parts which are interacting, interrelated, and/or interdependent elements that need to be considered for an educator to effectively integrate technology. From these findings, a technology integration framework was developed as a socio-ecological framework for mobile learning (Crompton, 2017). This framework highlighted the main supports educators need, at the school, district, and national level to integrate technology.

When COVID-19 necessitated the delivery of much instruction in an online environment, educators realized more fully how the successful integration of technology required more than the efforts of the classroom teacher. This broader need further highlighted the need to think about technology integration as a whole system rather than just placing the burden of responsibility on the shoulders of educators, as do frameworks such as TPACK and SAMR. Multiple members of the community need to be involved to ensure the successful use of technology for teaching and learning. A recent Covid -19 study by Crompton, et al., (2023) examined teacher resilience comparing the experiences of teachers across a developed country (US) with a developing country (South Africa) as they taught remotely with technology during the pandemic.

From the insights gained from this study, adaptations were made to the original technology integration framework (Crompton, 2017). The original factors connected to technology integration were examined and additions were made to become the SETI framework. For example, during Covid-19, it became apparent that families are a big part of the socio-ecological culture. Thus, families were added to the framework. Family refers to family culture and organizations. It also recognizes family customs and traditions, as well as the challenges of navigating shared workspaces and the responsibility of caring for others at home. Post lockdown, family still influences those that teach online and in person. Online

teaching requires the need to navigate workspace needs and both modalities have to consider family culture, bias, and perceptions of the efficacy of technology for teaching and learning.

In addition, the 2023 Covid study further emphasized the important role that entities beyond the school play in technology integration. Each entity has a role with school districts and local and federal governments ensuring that both students and teachers have the necessary tools and support needed for both teaching and learning. School districts provide additional training, tools, and technology support. National governments provide policies and guidelines to support effective technology integration as well as WIFI infrastructure. The application of the findings from the Crompton, et al., 2023 study resulted in this updated version of the SETI framework in Figure 3.

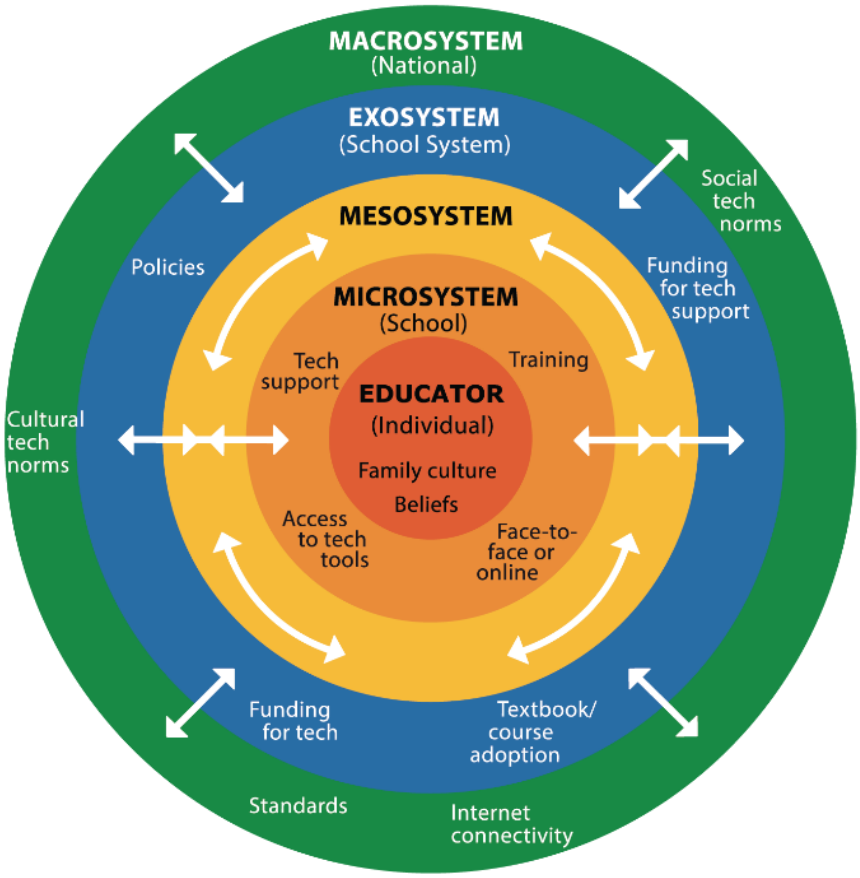

Figure 3. SETI Framework (Crompton, et al., 2023)

Unpacking the SETI framework

In the SETI framework, the concentric circles around the educator represent the various systems that determine how an educator integrates technology. These various systems all play a role in successful technology integration. In the center of the framework, the educator uses his/her beliefs and family culture to make decisions regarding technology integration. These beliefs are critical to the successful use of technology in education (Akram et al., 2022). If an educator does not believe that technology is useful in education, they will probably use it in a way connecting to this belief. This is also the case for positive beliefs about technology.

The second circle represents the microsystem of the immediate school setting surrounding the educator. This can include access to technology, students, training, technology support, and school leadership. Research by Peled and Perzon (2021) supports the need for school leaders to provide the guidance and leadership needed to effectively integrate technology. One of their findings revealed that without the schools' administration support, educators are more likely to continue using technology in the way they are most familiar but not necessarily the most effective. The third circle is the exosystem of the school district. This includes funding for technology support and training as well as policies. SETI provides school district leaders with a framework to examine the socio-ecological issues that are part of

the educational systems they manage to ensure that they are providing the best guidance and resources for effective technology integration.

The outer circle is the macrosystem. This represents how technology integration is mediated by the national environment, such as that nation's social, religious, and cultural norms, in addition to standards and internet connectivity. Current research supports the important role that governments play in effective technology integration. Research by both Alghamdi and Holland (2020) and Setia and Aufar (2023) indicate that government ICT policies have a positive influence on teachers' technology integration. The results of these studies indicated a need for governments to ensure both the financial and human resources needed for effective technology integration are provided. In addition, policies, strategies, and programs need to be enacted in a timely manner. The circle titled mesosystem uses arrows to highlight that a component of one system (e.g., policies) may also be found in the other systems. It highlights that each system is not independent of the other systems.

The framework has the educator at the center of the framework and highlights what the educator has to integrate technology with the goal of student success. However, the purpose of the framework is pinpointed at the students. Student learning is across all aspects of the framework. It is in the thinking and actions of the educator and the thinking and the actions of all in the socio-ecological system, including school/district leaders, technology coaches, technology support, government and federal leaders. They all have a role in technology integration in the SETI framework with the purpose of meeting the needs of the students.

A Whole Systems Approach

The SETI framework is important in reminding those in education that it takes "the community" as well as resource infrastructure to ensure successful technology integration. This means that educators are not working alone, and educational ecosystems must be examined and strengthened to provide all the support needed. The SETI framework also notes that cultural norms and beliefs play a role in technology integration. It reminds the broader community that national cultural and social tech norms factor into technology integration. For example, if a culture believes that online learning is ineffective, it is most likely that online technologies will not be integrated into education. Locations with positive connotations towards online learning are likely to have more funding and initiatives towards online learning. Within the center of the framework with the educators the word beliefs was written to emphasis the educator's beliefs towards technology and how these beliefs can make a difference in whether the educator chooses to use technology and how those tools are integrated into education (Akram et al., 2022; Crompton, 2017).

Implications for Practice

Educators can use the SETI framework to understand that they need a variety of human and structural resources for the effective integration of technology. Examples include technology support to solve technical issues as they arise, training to best understand how to use the various types of technologies with strategic pedagogical strategies, and policies to help guide effective, safe, and ethical use. Educators can use SETI to advocate for their needs while also reminding others that educators should not be working alone to integrate technology into education. SETI can also be used as a framework for educators to examine and reflect on their beliefs about technology and recognize that these beliefs have an impact on the success of the integration.

Educational leaders can use SETI as a framework to examine the socio-ecological issues that are part of the educational systems they manage. SETI is again a reminder to leaders that technology integration does not solely rest on the shoulders of educators in the classroom. Again, considering other factors, such as technology support, adequate training, and robust policies, is essential. Technology is often purchased and handed over to educators, who are expected to have all the pieces to ensure technology is successfully integrated into education. The SETI framework reminds the educational community that it takes all members of the community, local, regional, and national to ensure successful technology integration. This includes educators, school and district leadership, local government and community organizations, and national government and institutions. When this happens, educators are not working alone, and all parts of the educational ecosystem are working together to ensure student success.

Conclusion

The purpose of this paper was to describe the SETI framework and explain what it adds to the scholarly research regarding effective technology integration. While past frameworks, such as TPACK and SAMR

are helpful in allowing educators to think about technology integration, both frameworks fail to acknowledge the variety of the socio-ecological factors involved in technology integration. The SETI framework highlights that technology integration goes beyond technologies, pedagogies, and content and identifies that the educational systems surrounding the educator need to be acknowledged and aligned. The SETI framework includes technologies, policies, training, support, cultural norms, and personal beliefs.

The SETI framework can be used by educational leaders, technology coaches, and educators to ensure that all factors are considered to ensure effective integration. It is recommended that educators continue to use the TPACK and SAMR framework for a granular look at how the technology, pedagogy, and content knowledge intersect, and how technology is used. However, the SETI framework should be used to ensure that all the other factors that have to be taken into account.

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Acknowledgements

Not applicable

Funding

Not applicable.

Ethics Statement

Ethics review was not applicable for the manuscript as human subjects were not involved.

Conflict of Interest

The authors do not declare any conflict of interest.

Data Availability Statement

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Article History

Submitted: January 11, 2024 – Accepted: March 12, 2024

Suggested citation:
Crompton, H., Burke, D., Nickel, C., & Chigona, A. (2024). The SETI Framework and Technology Integration in the Digital Age. Asian Journal of Distance Education, 19(1), 167-177.
https://doi.org/10.5281/zenodo.10811077